Resonant Mechanics Thermodynamics Equations

Phase-Work, Coherence & Heat

Zachery Claude Maarschalkerweerd Jones

Abstract

This paper develops a thermodynamic formalism for *Resonant Mechanics*, a framework in which all physical change is *phase-work* on a chronotactic (time-ordered) lattice. Energy is counted phase-work, work is lane-pure (coherent) transport, heat is incoherent (dephased) flux, and entropy quantifies the dispersion of phase alignment. We define a coherence-based internal energy, state functions, and transport laws; derive resonant versions of the First and Second Laws; and introduce partition structures for statistical mechanics of phase. Limiting reductions connect the formalism to classical thermodynamics, quantum/radiative statistics, and curvature-coupled (gravitational) effects. In this view, equilibrium is harmonic stillness, irreversibility is broken coherence, and thermodynamics is the bookkeeping of resonance.

Contents

1 Notation & Context **2**

2 Thermodynamic Primitives (Resonant Form) **2**
- 2.1 Internal Energy . . . 2
- 2.2 Coherence Temperature . . . 3
- 2.3 Heat & Work (Phase Decomposition) . . . 3

3 First Law (Phase-Work Balance) **3**

4 Second Law (Coherence Entropy) **3**
- 4.1 Coherence Entropy . . . 3
- 4.2 Clausius Inequality (Resonant Form) . . . 4

5 Free Energies in the Resonant Metric **4**
- 5.1 Equation of State (Resonant Form) . . . 4

6 Statistical Mechanics of Phase (Partition Structure) **4**

7 Transport: Heat, Work & Entropy Production **5**
7.1 Constitutive Laws (Near-Laminar) 5
7.2 Work Rate (Coherent Power) 5

8 Maxwell-like Relations (Coherence Thermodynamics) **5**

9 Coherence Heat Capacities **5**

10 Phase Chemical Work & Photon/Neutrino Ledgers **6**

11 Equilibria & Extremals **6**
11.1 Canonical 6
11.2 Microcanonical 6
11.3 Laminar Reversibility 6

12 Limiting Reductions (Readability Crosswalk) **6**
12.1 Classical Thermodynamics 6
12.2 Quantum & Radiative Limits 6
12.3 Gravitational (Curvature) Coupling 7

13 Summary Statement **7**

1 Notation & Context

Resonant Mechanics views all dynamics as *phase-work* evolving on a chronotactic lattice. We reuse core fields:

- Θ_a : chronotactic angle field (local phase orientation),
- τ : proper chronotactic time (local rephasing cadence),
- ρ_{Flow} : phase-impedance density (inertial stiffness),
- Φ_{Form}, Φ_{Field} : boundary & stored potentials,
- $\mathcal{C}$: cosmological harmony constant (global register).

Dots denote $D/D\tau$. Spatial gradients use ∇_i and norms $\|\cdot\|$ under the ambient metric.

2 Thermodynamic Primitives (Resonant Form)

In Resonant Mechanics, *energy* is counted phase-work; *heat* is incoherent phase flux; *work* is coherent phase transfer; *entropy* measures loss (or dilution) of phase alignment.

2.1 Internal Energy

$$\boxed{U \;=\; \tfrac{1}{2}\rho_{\text{Flow}}\|\dot{\Theta}\|^2 \;+\; \Phi_{\text{Form}} + \Phi_{\text{Field}} \;+\; \tfrac{1}{2}\mathcal{C}\,\|\Theta\|^2} \tag{1}$$

2.2 Coherence Temperature

Temperature is the scalar that converts entropy increments into energetic cost of *dephasing*:

$$\boxed{\frac{1}{T} \equiv \left(\frac{\partial S}{\partial U}\right)_{\{\text{constraints}\}} \qquad \Longleftrightarrow \qquad \beta \equiv \frac{1}{k_B T}} \tag{2}$$

Here S is the *coherence entropy* (Sec. 4), and k_B is Boltzmann's constant (used as a scale for statistical counting).

2.3 Heat & Work (Phase Decomposition)

Decompose the energy flux into coherent and incoherent parts:

$$\boxed{\delta Q \;=\; \int d^3x \, \left(\mathcal{J}_{\mathcal{E}}^{\text{inc}} \cdot \hat{n}\right) d\tau, \qquad \delta W \;=\; \int d^3x \, \left(\mathcal{J}_{\mathcal{E}}^{\text{coh}} \cdot \hat{n}\right) d\tau} \tag{3}$$

where $\mathcal{J}_{\mathcal{E}}^{\text{inc}}$ carries incoherent (dephased) power, while $\mathcal{J}_{\mathcal{E}}^{\text{coh}}$ carries coherent phase-work. Operationally, coherent transport is aligned with $\dot{\Theta}$ and lane-pure; incoherent transport is phase-mixed.

3 First Law (Phase-Work Balance)

$$\boxed{dU \;=\; \delta Q \;-\; \delta W \;+\; dU_{\text{reg}}} \tag{4}$$

The term dU_{reg} represents *register exchange* with the global harmony channel ($\mathcal{C}$-term), e.g. slow gain/loss of global coherence.

Equivalently, in local balance form:

$$\boxed{\partial_\tau u \;+\; \nabla\cdot \mathcal{J}_{\mathcal{E}} \;=\; \sigma_{\text{coh}} \;-\; \sigma_{\text{diss}} \;+\; \sigma_{\mathcal{C}}} \tag{5}$$

with u the energy density, $\mathcal{J}_{\mathcal{E}} = \mathcal{J}_{\mathcal{E}}^{\text{coh}} + \mathcal{J}_{\mathcal{E}}^{\text{inc}}$, σ_{coh} coherent injection, σ_{diss} dissipative loss, and $\sigma_{\mathcal{C}}$ slow global register exchange.

4 Second Law (Coherence Entropy)

4.1 Coherence Entropy

Let $f(\varphi)$ be a normalized distribution of local phase orientations (on the circle or sphere of phases). Define

$$\boxed{S \;=\; -k_B \int d\varphi \; f(\varphi) \, \ln f(\varphi) \;+\; S_0} \tag{6}$$

S increases as phase disperses (loss of alignment). S_0 is a reference (e.g. perfect alignment baseline).

4.2 Clausius Inequality (Resonant Form)

$$\boxed{dS \;\geq\; \frac{\delta Q}{T} \qquad \text{with equality for strictly laminar (reversible) rephasing.}} \tag{7}$$

Thus, heat is the *price of lost alignment* and reversibility corresponds to adiabatic, lane-pure phase transport.

5 Free Energies in the Resonant Metric

Define the Helmholtz-like *coherence free energy*

$$\boxed{F \;=\; U - TS} \tag{8}$$

For systems under compressive geometry (pressure-like curvature load P and volume-like measure V),

$$\boxed{G \;=\; F + PV\,, \qquad dG \;=\; -S\,dT + V\,dP + \sum_i \mu_i\,dN_i} \tag{9}$$

where μ_i are *phase chemical potentials* conjugate to conserved coherence quanta N_i (photons, neutrinos, bound modes, etc.).

5.1 Equation of State (Resonant Form)

A minimal closure is

$$\boxed{P \;=\; -\left(\frac{\partial F}{\partial V}\right)_{T,\{N_i\}}, \qquad S \;=\; -\left(\frac{\partial F}{\partial T}\right)_{V,\{N_i\}}, \qquad \mu_i \;=\; \left(\frac{\partial F}{\partial N_i}\right)_{T,V,\{N_{j\neq i}\}}} \tag{10}$$

6 Statistical Mechanics of Phase (Partition Structure)

Let $\mathcal{H}[\Theta]$ denote the resonant Hamiltonian density associated with (1). The canonical partition functional is

$$\boxed{Z(T,V,\{N_i\}) \;=\; \int \mathcal{D}\Theta\; \exp\Big[-\beta \int_V \mathcal{H}[\Theta]\,d^3x\Big]} \tag{11}$$

and

$$\boxed{F \;=\; -k_B T\,\ln Z, \qquad \langle \mathcal{O} \rangle = \frac{1}{Z}\int \mathcal{D}\Theta\; \mathcal{O}[\Theta]\; e^{-\beta \int \mathcal{H} d^3x}.} \tag{12}$$

In the *laminar limit* (single lane, small fluctuations) this reduces to familiar canonical ensembles.

7 Transport: Heat, Work & Entropy Production

7.1 Constitutive Laws (Near-Laminar)

Write the entropy production rate as

$$\boxed{\dot{S} \;=\; \int_V d^3x \left(\mathcal{J}_{\mathcal{E}}^{\text{inc}} \cdot \nabla \frac{1}{T} \;-\; \mathbb{Q} : \nabla \dot{\Theta} \;+\; \sum_k J_k \, X_k \right) \;\geq\; 0} \tag{13}$$

where $\mathbb{Q}$ is a *coherence viscosity* tensor, J_k are generalized fluxes (e.g. species, helicity), and X_k their thermodynamic forces (gradients of potentials, chemical affinities, curvature misfits).

Linear near-laminar closures:

$$\boxed{\mathcal{J}_{\mathcal{E}}^{\text{inc}} \;=\; -\kappa \, \nabla T, \qquad \mathbb{Q} \;=\; \eta \, \nabla \dot{\Theta}, \qquad J_k \;=\; \sum_\ell L_{k\ell} \, X_\ell} \tag{14}$$

with κ thermal-like conductivity, η coherence-viscosity, and $L_{k\ell}$ Onsager-like coefficients (symmetric under time-reversal invariance).

7.2 Work Rate (Coherent Power)

$$\boxed{\dot{W} \;=\; \int_V d^3x \, \mathbb{T} : \nabla v_\Theta \qquad (v_\Theta \equiv \dot{\Theta})} \tag{15}$$

where $\mathbb{T}$ is the phase-work stress tensor (cf. prior motion/energy reports). Coherent pumping corresponds to $\dot{W} > 0$ at fixed or slowly varying S.

8 Maxwell-like Relations (Coherence Thermodynamics)

From $F(T, V, \{N_i\})$:

$$\boxed{\left(\frac{\partial S}{\partial V} \right)_{T,\{N_i\}} \;=\; \left(\frac{\partial P}{\partial T} \right)_{V,\{N_i\}}, \qquad \left(\frac{\partial \mu_i}{\partial T} \right)_{V,\{N\}} \;=\; -\left(\frac{\partial S}{\partial N_i} \right)_{T,V,\{N_{j\neq i}\}}} \tag{16}$$

and analogous triple-product rules follow.

9 Coherence Heat Capacities

Define constant-V and constant-P capacities:

$$\boxed{C_V \;=\; \left(\frac{\partial U}{\partial T} \right)_{V,\{N_i\}}, \qquad C_P \;=\; \left(\frac{\partial H}{\partial T} \right)_{P,\{N_i\}}, \qquad H \equiv U + PV.} \tag{17}$$

For weak curvature coupling (near-Euclidean V), $C_P - C_V$ is governed by phase-compressibility.

10 Phase Chemical Work & Photon/Neutrino Ledgers

Let N_γ and N_ν count photon and neutrino quanta participating in ledger closure (alignment and timing channels). Then

$$\boxed{dU \;=\; T\,dS - P\,dV + \mu_\gamma\,dN_\gamma + \mu_\nu\,dN_\nu + \sum_{i\notin\{\gamma,\nu\}} \mu_i\,dN_i} \tag{18}$$

with $\mu_\gamma \approx 0$ for ideal bosonic alignment channels in the grand-canonical limit, and small but nonzero μ_ν in weak chiral gates.

11 Equilibria & Extremals

11.1 Canonical

At fixed $T, V, \{N_i\}$, equilibrium minimizes F:

$$\boxed{\delta F \;=\; 0, \qquad \delta^2 F \;\geq\; 0} \tag{19}$$

11.2 Microcanonical

At fixed $U, V, \{N_i\}$, equilibrium maximizes S:

$$\boxed{\delta S \;=\; 0, \qquad \delta^2 S \;\leq\; 0} \tag{20}$$

11.3 Laminar Reversibility

A transformation is *reversible* if phase transport remains lane-pure and $\dot{S} = 0$:

$$\boxed{\delta Q_{\text{rev}} \;=\; T\,dS, \qquad \dot{S}_{\text{rev}} \;=\; 0} \tag{21}$$

12 Limiting Reductions (Readability Crosswalk)

12.1 Classical Thermodynamics

For near-isotropic media with negligible register exchange ($\mathcal{C} \to 0$) and without coherence-stress, Eqs. (4)–(17) reduce to the familiar first/second laws, F & G potentials, and Fourier/Onsager transport.

12.2 Quantum & Radiative Limits

For bosonic alignment channels (photons), the grand-canonical Z reproduces Planck distributions; for weak timing channels (neutrinos), Fermi statistics with chiral gating obtains. Quantization appears as periodic closure of Θ.

12.3 Gravitational (Curvature) Coupling

Pressure-like P is the conjugate of geometric volume; strong curvature modifies V & state equations via the ambient metric. Global register exchange ($\mathcal{C}$) contributes to effective vacuum-like energy.

13 Summary Statement

First Law: $dU = \delta Q - \delta W + dU_{\text{reg}}$
Second Law: $dS \geq \delta Q/T$ (equality for laminar, lane-pure transport)
Free Energies: $F = U - TS,\ G = F + PV$
Statistical Basis: $Z = \int \mathcal{D}\Theta\, e^{-\beta \int \mathcal{H} d^3x},\ \ F = -k_B T \ln Z$

In Resonant Mechanics, *heat* is the cost of lost phase alignment, *work* is lane-pure phase transport, and *entropy* measures dispersion of chronotactic orientation. Equilibrium is harmonic stillness; irreversibility is broken coherence. Thermodynamics becomes the bookkeeping of resonance.